Present State of Juniper in Rodhmallazi Forest of Balochistan, Pakistan

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Abstract

A quantitative Survey was conducted in 32 stands of juniper (*Juniperus excelsa* M. Bieb) in four adjacent districts of Balochistan. No other tree species was recorded in the study area. Vegetation composition of the juniper was described. Mean density of juniper was 105 individual ha^{-1} with a basal area of 18.4m^2 ha^{-1}. Juniper density and basal area were significantly correlated ($r = .35$, $P < .05$). Density of female trees was higher than male. Healthy trees produced only 21% of heavy (embryonic) seeds. Trees were slow growing (18 years/cm radial growth rate).

Leaves and soil analysis were also performed. Sandy clay loam with a calcarious nature was the dominant soil of the area. No correlation was observed between tree density; basal area and soil characteristics. Regeneration was absent. It is concluded that these forests are rapidly degrading due to human disturbance.

Introduction

The vegetation of Balochistan exhibits considerable variation due to diverse topography and distribution of rainfall (Rafi, 1965). Unpublished work has been carried out by the students of the Botany Department, University of Balochistan, in sub-tropical dry semi evergreen scrub. Ahmed *et al* (1990A) and Ahmed *et al* (1990B) described natural regeneration, structure and dynamics of four juniper forests in the dry temperate area of Balochistan. However, no quantitative sampling and soil analyses have been presented from the Rodhmallazi forest of Balochistan.

Due to increase in population, overgrazing and illegal cutting of dry temperate tree species, most of the area has been taken over by semi natural, disturbed communities or barren lands. It was though that the prevailing human disturbance would further alter the vegetational and soil pattern of these forests. Bearing these points in mind the study was conducted to obtain information on the present state of the juniper of this area.

The Study Area

The sampling area lies on the junction of Pishin, Zhob, Loralai and Ziarat districts (Fig.1) on Rodhmallazi. The area is located about 105 km northeast from Quetta city while the nearest town is Khanozai. The area is hilly and rugged with steep slopes and narrow valley. The highest peak is Dungan (2650m). Rocks of the Dungan formation belong to Paleocene to early Eocene age when the area was submerged under a shallow marine environment. Igneous rocks are volcanic breccia of basaltic composition embedded in calcite. Sedementary rocks are composed of limestone, shale and sandstone. All these rocks belong to the late cretaceous period. the nearest meteorological station is located at Ziarat (2451 m) about 25 km south. The record shows that the hottest month is July (27.4°C) while the coldest month is January (7.9°C). Relative humidity ranges from 35.3% in January to 60.1% in September. The area receives an annual rainfall of 269 mm with a maximum of 74.4 mm in July and minimum of 2.8 mm in January. Snow falls between November and April with a maximum (68.4 cm) in February. According to Champion *et al* (1965) the study area is included in the dry temperate forest type.

Materials and Methods

Around the junction of the four districts mentioned, 32 stands were sampled using Point Central Quarter method (Cottom and Curtis, 1956). In each stand 15 point were taken at 30 m intervals. Trees greater than 6 cm dbh (diameter at breast height) were included in this sampling. For herbs, shrubs and grasses, quadrats (size 2 x 2m) were made at each point and frequency of species was recorded. Following Mueller-Dombois and Ellenberg (1974) density and basal area were calculated.

In each stand the sex of each juniper tree was observed. Junipers of each stand were also divided into various categories: (1) Healthy = dark green colour with dense branches and leaves: (2) Unhealthy = dull colour with open branches and leaves; (3) Overmature = tree greater than 70 cm dbh with twisted, hollow, depressed or dead branches; (4) Disturbed = signs of broken or chopped branches; (5) Logged = logged stumps remain;

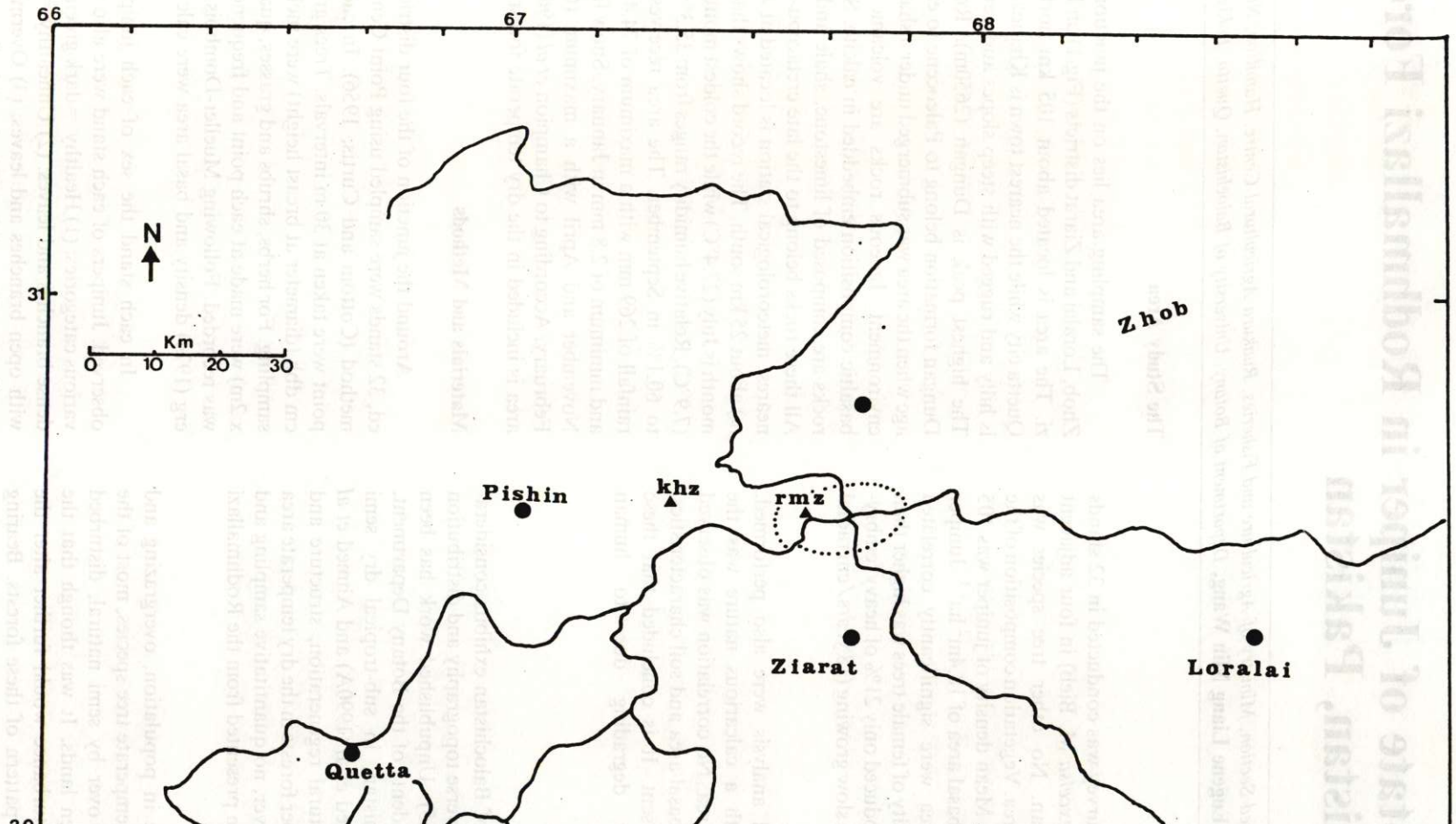

FIG.1

Map showiing 4 districts of Baluchistan.

Dotted lines indicated the sampling area. rm^2 (Rodhmallazi) and Khz (khanozai) are the nearest towns.

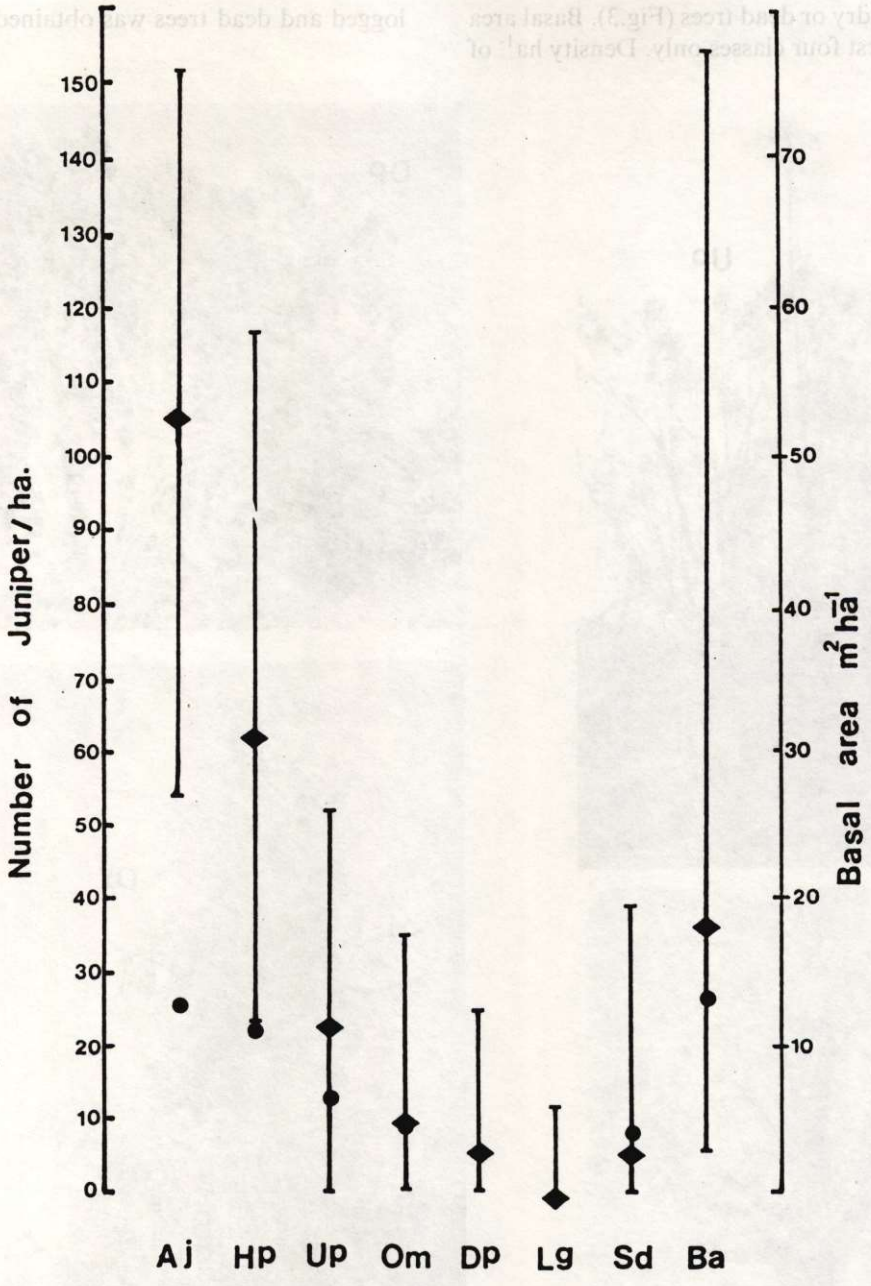

FIG 2

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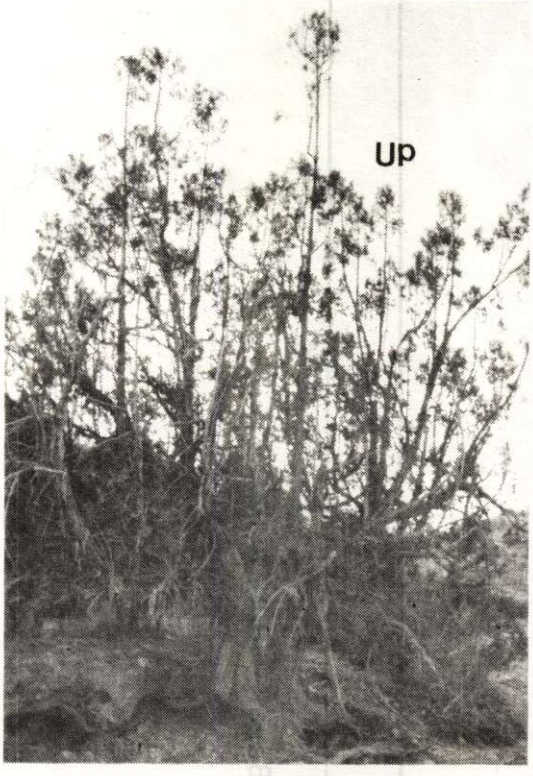
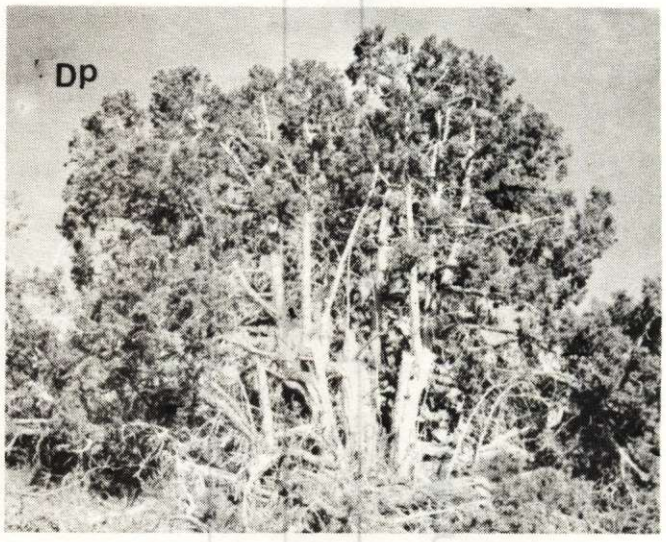
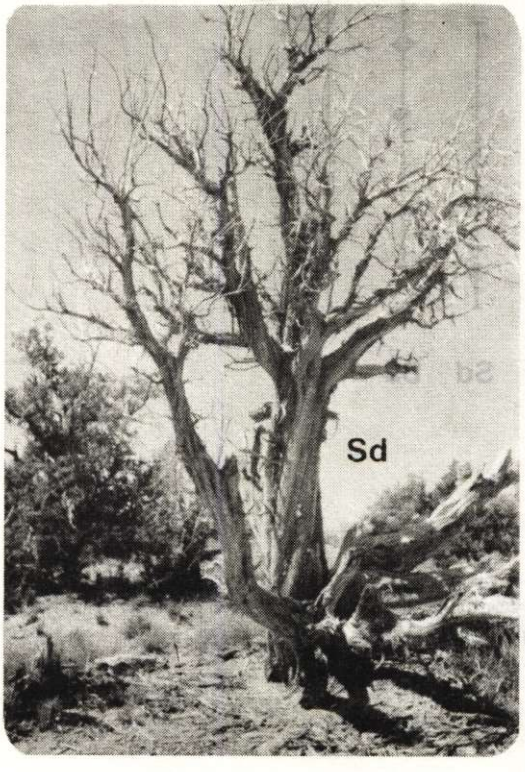
Graphical representation, of Juniper forest of the study area. All values are mean values of 32 stands. ♦ = mean value, ● = standard deviation. Vertical lines gives the range. AJ = Alive Juniper density ha^{-1}, Hp = Density of healthy Juniper, Up = Density of Unhealthy plants, Om = overmature Juniper, Dp = disturbed Juniper, Lg = logged stumpts, Sd = Standing dead plants, Ba = Basal area m^2 ha^{-1} of alive Juniper plants..

(6) Dead = standing dry or dead trees (Fig.3). Basal area was calculated for first four classes only. Density ha^{1-} of logged and dead trees was obtained separately.







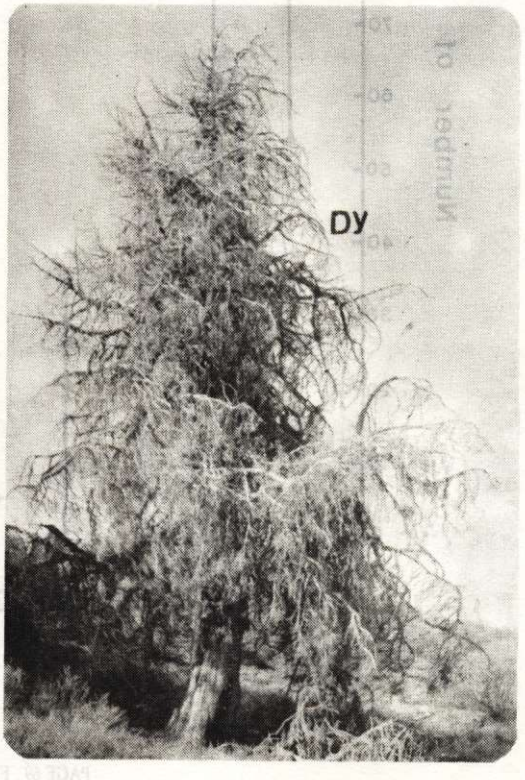
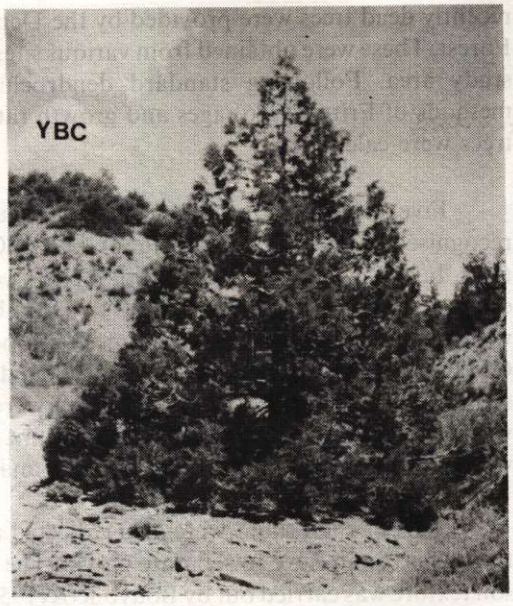
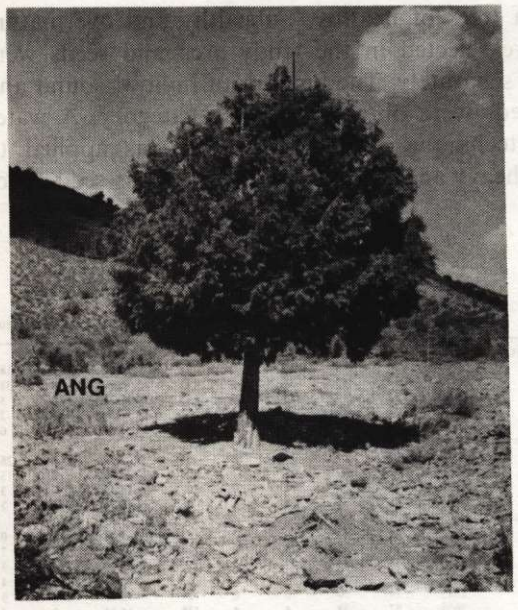
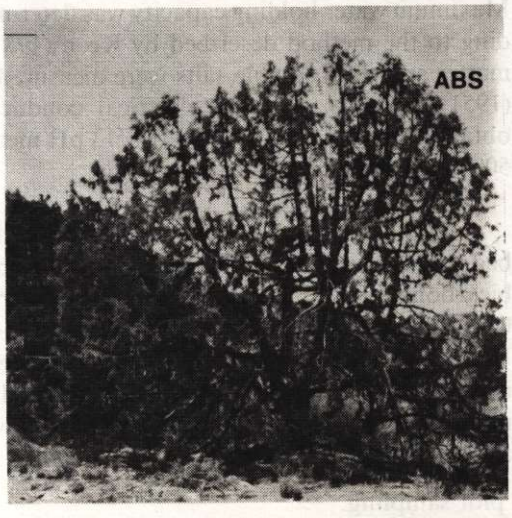
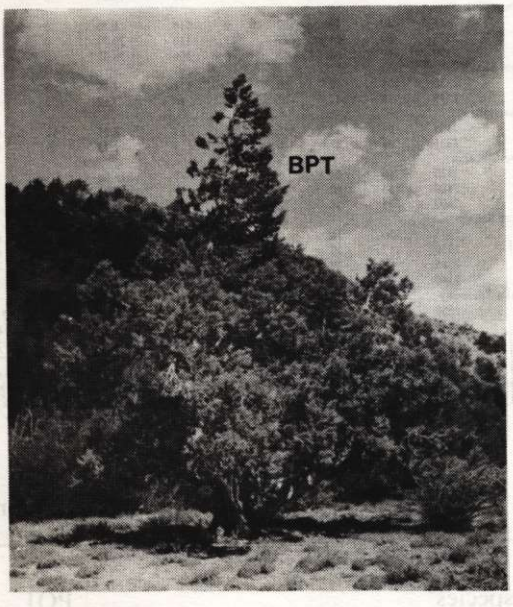


Fig 3. Showing present state of Juniper trees in the study area.
Up = A healthy plant. Roots are exposed due to soil erosion.
Dp = A disturbed plant. Branches and a few stems are chopped.
Sd = A standing dead tree.
Dy = A recently dead tree. All leaves are dry.









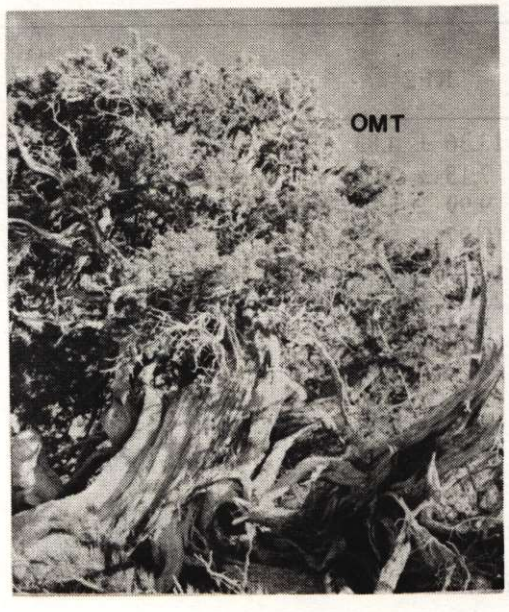


Fig. 4. A few morphological different forms of Juniper, selected for leaves analysis. Detail is given in material and methods.

Ten trees of healthy, unhealthy and overmature trees were selected in the study area and seeds were collected separately. The amount of hollow, sound and heavy seeds were obtained in each category. A water floating technique of Sheikh (1985) was applied to separate heavy and light seeds. Twelve cross-sections of recently dead trees were provided by the Department of Forest. These were obtained from various sites within the study area. Following standard dendrochronological methods of Fritts (1976) ages and growth rates of these trees were calculated.

Table 1. Summary of sites and stands

SN	ASI	EL2	HE3	UH4	OM5	DS6	AT7	BA8	LO9	DE10
A— Location, Ulgai										
1	SE	2630	76	6	15	0	97	20.66	3	18
2	W	2620	84	13	34	0	131	76.90	0	38
3	N	2640	57	15	23	0	95	27.21	0	5
4	N	2625	43	48	0	3	94	13.9	0	2
5	E	2610	30	18	3	3	54	4.68	3	0
B— Location, Sarnaffar										
6	NW	2570	52	52	15	12	131	27.39	0	28
7	N	2580	51	27	23	2	104	27.00	0	15
8	NW	2620	63	36	8	0	107	12.33	0	3
9	SW	2605	68	15	8	5	96	16.35	3	2
C— Location, Wulgai										
10	E	2635	36	18	-	3	57	3.20	0	0
11	N	2590	75	39	14	7	135	23.07	0	7
12	NW	2590	38	23	29	23	113	37.10	0	3
13	E	2580	22	26	13	10-	71	17.92	0	4
14	W	2635	74	50	0	0	124	8.77	0	0
15	E	2650	92	38	4	4	138	14.24	0	4
D— Location, Near Wulgai										
16	E	2645	80	24	12	0	116	8.56	0	3
17	NW	2575	50	25	19	25	119	27.77	0	7
18	NW	2570	69	8	23	6	106	28.82	0	8
E— Location, Pani Shakh										
19	N	2350	108	0	0	3	111	4.89	6	0
20	W	2335	78	12	3	3	96	7.12	2	0
F Location, Chachobi										
21	E	2355	61	12	5	4	82	8.25	12	0
22	NW	2325	68	31	6	18	123	12.93	0	0
G— Location, Shalla Kazza										
23	NW	2320	60	21	8	8	97	14.88	3	5
24	S	2480	36	10	112	9	67	15.81	0	2
25	NW	2600	73	16	2	0	91	14.66	0	3
H— Location, Tore Sakhar										
26	N	2595	100	16	3	0	119	10.26	0	6
27	W	2550	117	27	0	8	152	10.76	4	0
28	NW	2585	36	39	24	12	111	27.06	0	9
29	S	2560	29	29	7	2	67	17.34	0	5
I Location, Shalla Sparoony										
30	W	2550	82	52	17	0	151	25.68	0	21
31	W	2625	80	16	13	10	119	15.71	3	6
32	N	2595	42	23	6	4	75	8.76	0	2

SN = Stand number; ASI - Aspect: EL2 = Elevation in meters; HE3 = Healthy plants ha^{-1} ; UH4 = Unhealthy plants ha^{-1} ; OM5 = Overmature plants ha^{-1}; DS6 = Disturbed plants ha^{1-} ; AT7 = Density of alive juniperus tree ha^{-1}; BA8 = Basal area m^2 ha^{-1} of alive juniperus trees; LO9 = logged stumps ha^{-1} ; DE10 = Dead standing trees ha^{-1}

Five different morphological forms of juniper were recognised in the study area (Fig. 4), i.e. YBC = young trees, bushy from with conical top, ANG = young trees, clear stem with rounded top, ABS = large bushy trees with spherical top, BPT = large trees with pointed top, OMT = overmature trees (more than 70 cm dbh, twisted stem). Leaves from 5 trees of each form were collected, washed and oven dried at 80°C for 24 hours. Dry leaves were grounded and digested for element analysis.

Soils of each stand were also collected and passed through a 2 mm sieve to separate gravel. The analysis of soil texture was carried out by Bouyoucos (1951) method. Maximum water holding capacity was determined according to the method described by Keen (1931). Organic matter and total soluble salts were measured by USDA (1951) methods. pH and electrical conductivity were obtained using a Philips No 9418/13 pH meter and EIL 5003 conductivity meter respectively.

Soil $CaCo_3$ was determined by the method described by Qadir *et al* (1966) while for carbonate and bicarbonate Reitemeier's (1943) methods were followed. Chlorides were determined by USDA (1954) method. Micro and macro elements of soil and leaf were determined in DFDC Laboratories, Quetta. Methods described in a handbook "Plant Analysis" were followed for soil and leaf analysis.

Table 2. Summary of plot sampling.

Name of species	PO1	RF2	RA3
1. Acantholimon longiflorum	31	13.36 ± 4.83	3.22 – 19.44
2. Allium dolichostylum	24	7.15 ± 3.23	2.22 – 17.70
3. Artimisia maritima	31	9.99 ± 5.12	2.22 – 17.24
4. Caragana ambigua	27	10.97 ± 5.90	2.12 – 30.76
5. Causinia ambigua	29	13.70 ± 4.77	4.44 – 21.27
6. Ephedra intermediata	30	20.69 ± 4.47	2.77 – 21.42
7. Nepeta juncea	29	6.50 ± 4.59	1.88 – 22.22
8. Pennisetum oriental	31	21.90 ± 4.33	13.72 – 30.30
9. Perovskia abrotanoides	3	7.0 ± 6.02	2.32 – 13.79
10. Prunus brahuica	32	12.60 ± 4.79	6.38 – 20.68
11. Thymus serpyllum	5	5.17± 2.77	2.22 – 9.75

PO1 = Number of stands in which a species occurs
RF2 = Mean relative frequency with standard deviation
RA3 = Range of relative values

Table 3. Summary of seed characteristics of juniper

Physical appearance of juniper	Morphologically		Water floating technique		
	Hollow seed	Sound seed	Heavy seed 1	Heavy seed 2	Light seed
Healthy	23.8 ± 2.1*	76.2 ± 2.1	24.7 ± 6.5	20.6 ± 3.9	79.3 ± 3.9
Unhealthy	24.5 ± 5.6	75.4 ± 5.7	18.3 ± 8.5	20.8 ± 6.9	79.2 ± 6.9
Overmature	25.0 ± 8.1	74.8 ± 8.6	12.7 ± 1.5	15.2 ± 4.2	84.8 ± 4.2

All values are mean values presented in percentages.
In each category 10 trees were taken and 100 seeds were randomly taken from each tree.
Heavy Seed 1 = water floating technique applied before separation the morphologically hollow seeds.
Heavy seeds 2 = water floating technique applied using sound seeds only.

* Standard deviation

Table 4. Age and growth of *Juniperus excelsa*

S.No.	Diameter cm	Growth rate y/cm	Total Age years	Elevation m	Aspect
1	20.0	12.01± 2.71	113	2570	NW
2	21.0	16.72± 2.16	219	2570	NW
3	28.4	8.70± .36	235	2585	NW
4	33.0	20.27± 3.79	744	2320	NW
5	11.8	33.19± 8.85	205	2320	NW
6	18.0	10.28± 1.77	114	2320	NW
7	28.2	6.36± 1.38	111	2580	N
8	25.2	18.15± 2.12	418	2480	S
9	24.5	11.36± 1.14	209	2480	S
10	27.0	23.07± 8.96	337	2645	E
11	19.5	9.0 ± 1.71	121	2645	E
12	28.5	37.93± 1.16	537	2645	E

overall x g rowth rate = 18 ± 10.21 years/cm

Results

Juniperus excelsa M. Bieb is the only tree species of the sampling area therefore relative phytosociological attributes (frequency, density and basal area) and importance values are not discussed. These forests are described here on the basis of density and basal area per ha. Nearest locations, aspect, elevation and density/basal areas of various categories of juniper are given in Table 1. A graphical summary of the overall juniper forest of the study area is presented in Fig.2.

In the present study area juniper grows from 2320 m to 2650 m. Most of the stands are on east, north and west facing slopes, with a few on southerly slopes. Density of juniper ranged from 54 to 152 ha^{-1} with a mean of 105+25 individuals ha^{-1}. Basal area of juniper ranged from 3.2. to 76.9 m^2 ha^{-1}. The basal area and density of juniper were highly variable both within and between sites (Table 1), however these values were significantly correlated ($r = .35$, $P < .05$). A large number of juniper trees were unhealthy. Recently logged trees were less in number (x 1 tree ha^{-1} but 12 trees ha^{-1} were logged from Chachobi area. Standing dead trees were recorded from 0-38 individual ha^{-1}. Number of male and female plants are not given in the table, however, male juniper were recorded from 2 to 67 ha^{-1} with an average of 23 individuals ha^{-1}. Density of female plants was much higher than male. An average 44 females ranging from 18 to 65 plants ha^{-1} was obtained. Bisexual plants were rare ranging from 0 to 15, with an average of 2 plants ha^{-1}.

During the plot sampling only 11 speices were recorded and no juniper seedlings (less than 6 cm dbh) were observed in the study area. Table 2 shows that *Causinia ambigua, Ephedra intermediata, Pennisetum oriental, Artimisia maritima, Acantholimon longiflorum* and *Prunus brahuica* were the most widely distributed species of the study area, associated with juniper in 29 to 32 stands. Other species like *Allium dolichostylum, Nepeta juncea* and *Caragana ambigua* were recorded in 24 to 27 stands.

A study of seed characteristics of juniper (Table 3) shows that as far as the amount of hollow (due to insects) or sound seeds are concerned, there is no difference among healthy, unhealthy or overmature juniper trees. However, the amount of heavy seeds reduces (13%) in overmature trees.

Tree age and radial growth rate are shown in Table 4. Since all wood samples were in the form of cross-section, they were considered 100% reliable. Age and growth rate varies from tree to tree even among similar sized

trees. For example, individuals of 28 cm dbh (3, 4, 12. Table 4) attain ages of 111 years, 235 years, and 537 years with growth rates ranging from 6 to 38 years per cm. The overall radial growth rate of the 12 cross-sections was 18 years per cm.

A summary of element analysis of juniper leaves from five morphological forms is given in Table 5. The highest amount of iron (227 ppm) and manganese (.21g/100g) was obtained from ABS type juniper, while BPT type individuals of juniper showed maximum potassium (.79 g/100 g) with lowest amount of nitrogen (.80 g/100 g) phosphorous (.10 g/100 g), manganese (.12 g/100 g) and zinc (10.2 ppm). However, no significant differences were found among these morphologically different forms in the amount of any elements.

The dominant soil of the area is sandy clay loam. Average composition and nutrient values are given in Table 6. Unpublished soil analysis data from juniper forest of Kuch, Babakhurwari and Ziarat is also given in the same table for comparison. Soils of the present study area showed great variability in each variable. Water holding capacity ranged from 21 to 41% while the amount of organic matter ranged from .73 to 5%. Only overall average values are given in Table 6. All soils showed pH greater than 7.8. Electrical conductivity, pH, $CaCo_3$ HCO_3 and CI had a comparatively stable distribution in 32 stands, with low standard deviation. Since soil variables do not show any significant relation with juniper density and basal area, values of correlation coefficient are not presented in the table.

Discussion

Juniperus excelsa forms pure, open and unstratified stands in the area studied. Human activity (cutting and overgrazing) has completely changed the vegetational composition of the area. No broad leaf tree species now exist in these forests. Only 11 species of herbs, shrubs and grasses were associated with juniper, while 20 species were reported by Shafeeq (1987) from Ziarat juniper area.

Density of juniper trees from juniper tract ranged from 56 to 332 ha^{-1} (Ahmed *et al,* 1990B). *Pinus gerardiana* forest of the Zhob District showed an average of 226 individuals ha^{-1} with a range of 24 to 930 trees ha^{-1} (Ahmed et al, 1990A). In comparison to these nearby forests, the density of this juniper forest ranged from 54 to 152 ha^{-1} with an average of 105 +25 individuals ha^{-1}. The overall mean basal area of present juniper forest (18 m^2 ha^{-1}) was also lower than juniper tract (41 m^2 ha^{-1}) and *Pinus gerardiana* forest (25.5 m^2 ha^{-1}).

Ahmed *et al* (1990B) also calculated densities of healthy, overmature and disturbed juniper individuals on the juniper tract (from Kuch to Chautair). Higher densities of healthy (61 to 76%) and overmature individual (18 to 32%) were reported by these workers. The present study area showed 60% healthy juniper trees with 23% unhealthy individuals. Overmature trees occupied only 10% of the total density probably due to cutting and logging of large trees. In many stands large number of standing dead trees (upto 38 ha^{1-}) were also recorded while this situation did not exist in the juniper tract in the same province. A higher number of female individuals were recorded in the study area while according to Ahmed *et al* (1990B) male: female ratio was 1:1 on the juniper tract. Bisexual plants were rare in both places.

Unlike the juniper tract and *Pinus gerardiana* forests of the same province no seedlings (up to 6 cm dbh) were recorded in the study area. According to Ahmed *et al* (1989A) juniper seedlings required shade in their early stage of development, therefore it is likely that exposed soil surface, distance between juniper trees and low vegetation cover with overgrazing were responsible for lack of natural regeneration in the study area. Regeneration studies on the juniper tract (Ahmed *et al,* 1989A) and present study suggested that this area has not been producing seedlings for the last 60 to 100 years or seedlings were destroyed either by human disturbance or as a result of open canopy of the forest. Therefore, if these forests are regulated now, in future there would be a 60-100 years "regeneration gap" in the size class structure of juniper trees.

A detailed study of seed characteristics from the juniper tract (Ahmed *et al,* 1989B) showed that overmature juniper trees produced 35% of hollow seeds with 19% of heavy seeds. The present study showed fewer heavy seeds (15%) in overmture trees.

Age and growth rate data from nearby dry temperate forests was also available. Overall growth rate of *Pinus gerardiana* trees was 12 years/cm (Ahmed *et al,* 1990A), while juniper trees from the juniper tract showed 10 years /cm) radial growth (Ahmed *et al,* 1990B). Slowest radial growth (18 years/cm) was recorded in the study area which may be related with poor soil condition of the study area. Du to great variability in age and growth rate (even among the same sized individuals) the present study confirms that diameter is a poor indicator of age and growth rate, as reported by Ahmed *et al* (1990A,B) from other forests of the same province.

This study presents the first element analysis of a tree species in Balochistan. Following Achakzai (1982) juniper leaves may be described as low in K, P, higher in CU and very high in Mn, Zn and Fe, Juniper leaves had a higher amount of Zn , Fe, Mn, CU and N than the soils

Table 5. Summary of leaves analysis of *Juniperus excelsa*

Type of tree	No.of tree	% (g/100g dry matter) N	P	K	Ca	Mg	Cu	PPm (Ug/g dry matter) Mn	Fe	Zn
1. YBC	5	0.93± .03	0.13 ±.01	0.40±.20 *(.24-.62)	1.35± .13	.12± .12	2.67± .57	31.88± 2.96	280.9± 84.3 (196.6– 365.3)	12.92± 2.82
2. ANG	5	0.88± .09	.10 ±.03 (.06–.13)	.27±.08	1.13± .15	.17± .07 (.09–.24)	2.57± .59	26.74± 3.42	313.88 ± 64.19 (232.8–705.4)	12.28± 3.08 (8.64–16.12)
3. ABS	5	0.90± .10	.11 ±.02	.33±.07	1.4± .17	.21± .03	2.66± .67	26.63± 5.11	326.68 ± 98.91 ((208.7–469.6)	12.49± 6.12 (7.58–22.54)
4. BPT	5	.80± .12	.10 ±.01	.79±.87 (.24–1.8)	1.52± .87	.12± .05	2.22± .73 (1.38–2.75)	30.36± 10.15 (22.8–41.9)	289 ± 41.74	10.16± 2.07
5. OMT	5	1.0± .42 (.06–1.02)	.11 ±.02	.32±.08	1.32± .18	.15± .04	2.52± .97 (1.61–3.66)	27.29± .60	261.87 ± 31.31	11.59± 4.81 (7.58–13.99)
Overall mean	25	.84± .21 (.06– 1.02)	.11 ±.02 (.06 –.14)	.32±.10 .14–.62)	1.32± .20 (.97– 1.63)	.16± .05 (.09– .25)	2.54± .65 (1.38– .66)	28.11± 4.91 (19.2– 41.91	298.05 ± 68.04 (196.6 – 469.6)	11.97± 3.95 (7.58– 22.54)

* Range is given where the values of standard deviation are higher.

Table 6. Summary of soil characteristics of four juniper forests of Balochistan.

	Soil Character		Study Area*	KUC1	BAB2	ZIA3
1	Sand %		46.4± 11.0	61.4± 11.9	79.7±3.9	80.6±3.9
2	Silt %		21.4± 6.1	22.2±8.8	14.9±3.0	12.8±2.4
3	Clay %		32.6± 4.4	16.4±4.1	5.2±2.0	6.7±1.8
4	Soil texture class		Sandy Clay Loam	Sand Loam	Loamy Sand	Loamy sand
5	Organic matter%		2.0± 1.1	1.2± .3	2.0±1.1	1.7±1.2
6	Water holding capacity%		26± 5.3	37.8±15.5	23.5±6.3	30.9±6.00
7	pH %		7.9± .1	7.8±.1	7.8±.25	7.7±.4
8	Electrical Conductivity		1.5± .2	1.9±.4	.3±.2	.5±.2
9	Calcium Carbonate. $CaCo_3$		16.7± 6.1	16.6±4.4	16.9±5.7	21.4±4.3
10	Carbonate. Co_3		1.5± .4	NA	4.6±1.5	2.8±1.5
11	Bicarbonate. HCo_3		2.7± .6	1.3±.2	NA	NA
12	Chloride, Cl		4.6± 1.1	.4± .2	1.1± .7	4.9±.2
13	Sulphate, So_4		NA	.1± .05	NA	NA
14	Total soluble salts, T.S.S.		.03±.0007	.2± .03	NA	NA
15	Total Nitrogen,	N	.09±.04	NA	NA	NA
16	Phosphorus,	P	3.0±2	5.0±1.9	NA	NA
17	Potassium,	K	1.07±30.7	366±88.6	NA	NA
18	Copper,	Cu	1.4±1.1	NA	NA	NA
19	Manganese,	Mm	13.8±6.6	NA	NA	NA
20	Iron,	Fe	16.7±8.9	NA	NA	NA
21	Zinc,	Zn	.6±.3	NA	NA	NA
22	Ca + Mg		NA	1.7±.32	NA	NA

1 = Kuch arrea by Buzdar (1987)

2 = Babakhurwari area by Ahmed (1987)

3 = Ziarat area by Shafeeq (1987). In each area summary is based on 45 composite soil samples.

* based on 96 composite soil samples of 32 stands.

NA = not analysed

while soils had higher amount of K and P than the leaves.

Sandy clay loam was the supporting soil of the study area. Due to overgrazing and erosion in many places bare rocks were exposed. Soils were basic and moderately calcareous in nature with medium water holding capacity. The amounts of CI, P and Zn was low while CU, Mn and Fe were at a very high level. The amount of K was medium. Buzdar (1987), Ahmed (1987) and Shafeeq (1987) carried out a soil survey in the juniper tract. In most cases the present results were similar to these workers. However, the amount of carbonate, total soluble salts, phosphorous and potassium was considerably less in the present study area while bicarbonate and clay were higher. No significant correlations were obtained between juniper density: basal area and soil characteristics, probably due to the disturbance.

Low density, lack of regeneration, higher numbers of unhealthy plants, standing dead trees, low vegetation cover, exposed soil surfaces, slow growth rate and lack of correlation between juniper density: basal area and edaphic variables are all the result of human disturbance. Therefore, it may be suggested that these juniper forests have degraded extensively.

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